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(54) Terminations for mineral insulated electric cables

(57) A termination for a mineral-insulated electric cable comprises a pot filled with a permanently pasty and permanently adherent sealing medium that is convertible to a ceramic body under fire or other conditions exceeding the intended working temperature. The sealing medium includes a mineral filler, eg. bentonite, talc, kaolin and other clays, magnesium silicate, mica, magnesium oxide, zinc oxide, glass and mixtures of these and a fluid organic binder, eg. a non carbonisable silicone.

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SPECIFICATION

Terminations for mineral insulated electric cables

This invention relates to terminations for electric cables of the kind having a metal sheath and insulation of compacted mineral powder which fills the sheath (mineral insulated cables). Such cables are inherently resistant to heat and to fire exposure and will continue to function unless the metal sheath is melted or destroyed by oxidation; for example, a mineral insulated cable with copper conductors and sheath will function for several hours at 1000°C in air of normal atmospheric composition.

However, the mineral insulation of such cables is sensitive to moisture, and the terminations currently used to provide a moisture-proof seal are much less resistant to heat and fire than the cables are, and may cause system failure when the cables themselves are still in a serviceable condition.

The present invention provides terminations with fire-performance characteristics comparable with those of the cables.

In accordance with the invention, a mineral-insulated cable termination including a sealing pot secured to the cut-back end of the cable sheath and enclosing the whole of the mineral insulation that is exposed at the cut-back end of the sheath together with an adjacent section of the, or each, exposed cable conductor and filled with a permanently-pasty and permanently-adherent sealing medium comprising a mineral filler and a fluid organic binder is characterised by the fact that the sealing medium is convertible to a ceramic body on heating sufficient to pyrolyse and/or volatilise the organic binder.

Preferably the pot is made of a material or materials at least as heat-resistant as the cable, but this is not essential as the ceramic body formed under fire conditions may (in favourable cases) be adequate to maintain a minimum level of insulation resistance even though the pot has been melted or otherwise destroyed: thus a conventional brass pot with an organic closure disc may be acceptable. Otherwise a stainless steel or copper pot with a ceramic closure disc is recommended.

The sealing medium must have a high adhesive affinity for the metal(s) of the cable sheath and conductor(s) as well as for the mineral insulation; and it must be convertible to ceramic form at a temperature above the maximum service temperature but not substantially higher than the highest temperature which the pot will withstand. For use with standard mineral-insulated cables in which the metal components are of copper, we prefer that conversion to ceramic form is rapid in at least part of the temperature range from 500 to 800°C.

Suitable mineral fillers include bentonite, talc, kaolin and other clays, magnesium silicate, mica, magnesium oxide, zinc oxide, glass, and mixtures of these. Silica can be used in admixture with one or more of these.

Since carbon-base organic binders are liable to carbonisation in at least some high-temperature conditions, we prefer to use a non-carbonisable silicone binder and more especially those silicone polymers which decompose in the solid state to leave a residue of silica which contributes positively to the ceramification process; these requirements are met by the 'copolymeric siloxanes' in which there is a structural framework consisting essentially of silicon and oxygen atoms only with carbon-based side-chains all attached *via* side-chain silicon atoms, and the Applicants at present believe that this structure is necessary among silicone binders. Suitable polymers can be made by hydrolysis and co-condensation of a tetrafunctional silane and a trialkyl monofunctional silane, e.g. tetra ethoxy silane and trimethyl ethoxy silane (or their chloro analogues) as more fully described in UK Patent 2046283B (and see also US Patent 2676182). So far as the applicants are aware, such polymers are not at present offered on the open market as such, but they are believed to be made and used in the manufacture of silicone adhesives and coatings. Silicone binders suitable for use in the invention and thought to be of this kind can be extracted from the adhesives sold by Dow Corning Limited under reference numbers 280A and 282 and the coating sold under the designation 'Toray Silastic TS1417'.

A proportion of a silicone, such as a silicone fluid, which decomposes at least partly in the vapour phase to give a powdery silica deposit may be present, and is helpful in securing the required ambient-temperature properties. Ordinary polydimethyl siloxane fluids are suitable for this purpose.

The ceramifiable silicone adhesives described in U.S. Patent 4255316 may be suitable for use as the sealing medium of the present invention, or the proportion of the ingredients may be varied to secure better ambient physical and adhesive properties.

Example 1:

Toray Silastic TS1417 appears to be a dispersion of mica in a solution in xylene of a first silicone polymer (polymer A) of the kind described in U.S. Patent 2676182 and a second silicone polymer (polymer B) designed to flexibilise the coating (curing agents would be added when the material is conventionally used).

The coating material (as bought and without any curing agent) was centrifuged to separate the mica and the resulting clear solution was mixed with a silicone fluid sold by Dow Corning Limited under the designation Silicone Fluid

DC200/300,000 cs and with a filler-grade talc (−200 mesh, less than 70μm) in the ratio of three parts silicone fluid and 60 parts talc to each ten parts of total polymer A and B. The xylene was removed from the mixture by distillation at 160°C to give a putty similar in consistency and adhesiveness to conventional mineral-insulated-cable termination sealants.

A 2.5m length of a 440/600V 2-core 3mm^2 copper-conductor copper-sheathed mineral insulated cable was terminated at one end with a conventional seal. An experimental termination was made by stripping back 1.2m from the other end, screwing on a conventional brass pot and filling it with the putty just described. A closure disc of hard silicone rubber was applied.

The cable was loaded at 500V d.c. and 250mA using a load resistor and a 3-phase transformer, and voltage withstand tests made at intervals by applying 2kV A.C. for 1 minute.

No significant change in electrical properties were detected on heating the experimental termination (without any gland or other protection) in a furnace at 920°C for 30 minutes. On inspection after cooling it was found that the brass pot had melted but the putty had been converted to a ceramic body with sufficient cohesion to prevent the melted brass from shorting across the conductors. (no impact was applied during this test).

Example 2

In a fully-synthesised example, 15.6g of tetraethoxy silane and 13.3g of trimethyl ethoxy silane were dissolved in a mixture of 40 ml ethanol (industrial methylated spirit, 'denatured' by addition of small amounts of methanol), 10 ml water and 0.4 ml of 1N hydrochloric acid. The solution was refluxed for 8 hours and the solvents removed by evaporating under atmospheric pressure at 100°C. A polymeric silicone condensate was obtained as a viscous liquid.

This was mixed with china clay powder (Grade E, from ECC International Limited, predried at 200°C for 3 hours) in the proportion 5 parts of the product, 8 parts of china clay to produce a putty substantially equivalent to the one prepared and used in Example 1.

Examples 3–6

In each of these examples, 100 parts of Dow Corning silicone adhesive 280A (55 parts solids) was mixed with 27.5 parts Dow Corning silicone fluid 200/60,000 cS and with fillers as follows (all predried at 200°C for 3 hours):

Example 3: 132 parts china clay powder, grade E;

Example 4: 82.5 parts china clay powder, grade E and 165 parts magnesium oxide (grade HMD5 fron Steetley Refractories Limited);

Example 5: 74.5 parts of calcined clay (sold under the Trade Mark Polestar 501 by ECC International Limited) and 149 parts of magnesium oxide, grade HMD5

Example 6: 66 parts of calcined clay (Polestar 51) and 132 parts of silica flour (grade 35/200S from Richard Baker Harrison Limited).

Solvent was evaporated at 150°C to give in each case soft, sticky mastic putties. They were packed into standard mineral-insulated cable terminations, and each passed the water ingress test of British Standard BS 6081.

The terminations made with the putty of Example 4 passed the fire test according to IEC Specification 331 (3 hours at 750°C in a gas flame, carrying rated voltage while fused at 3A) and also withstood 15 minutes at 850°C in a tube furnace. In all of these examples, the mastic putty was converted, on application of a flame, to a ceramic body sufficiently coherent to avoid conductor-to-conductor short circuits (but not to maintain water resistance).

It is our present view that a putty somewhat higher in silicone fluid content than these examples will be optimum for use in the pre-assembled termination described in our earlier British application No. 8518008.

CLAIMS

1. A mineral-insulated cable termination including a sealing pot secured to the cut-back end of the cable sheath and enclosing the whole of the mineral-insulation that is exposed at the cut-back end of the sheath together with an adjacent section of the, or each, exposed cable conductor and filled with a permanently-pasty and permanently-adherent sealing medium comprising a mineral filler and a fluid organic binder characterised by the fact that the sealing medium is convertible to a ceramic body on heating sufficiently to pyrolyse and/or volatilise the organic binder.

2. A termination as claimed in Claim 1 in which the mineral filler is selected from bentonite, talc, kaolin and other clays, magnesium silicate, magnesium oxide, zinc oxide, glass and mixtures of these.

3. A termination as claimed in Claim 1 in which the mineral filler is mica.

4. A termination as claimed in Claim 1, Claim 2 or Claim 3 in which the binder is a non-carbonisable silicone having a structural framework consisting essentially of silicon and oxygen atoms only with carbon-based side-chains all attached *via* side-chain silicon atoms.

5. A termination as claimed in Claim 4 in which the binder also includes a silicone fluid.

6. A mineral insulated cable termination substantially as described with reference to Example 1.

7. A mineral insulated cable termination filled with a putty substantially as described with reference to Example 2.

8. A mineral insulated cable termination filled with a putty substantially as described with reference to Example 3, Example 5 or Example 6.

9. A mineral insulated cable termination substantially as described with reference to Example 4.

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